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(56) Documents Cited
EP 0580269 A2 **EP 0087123 A2**

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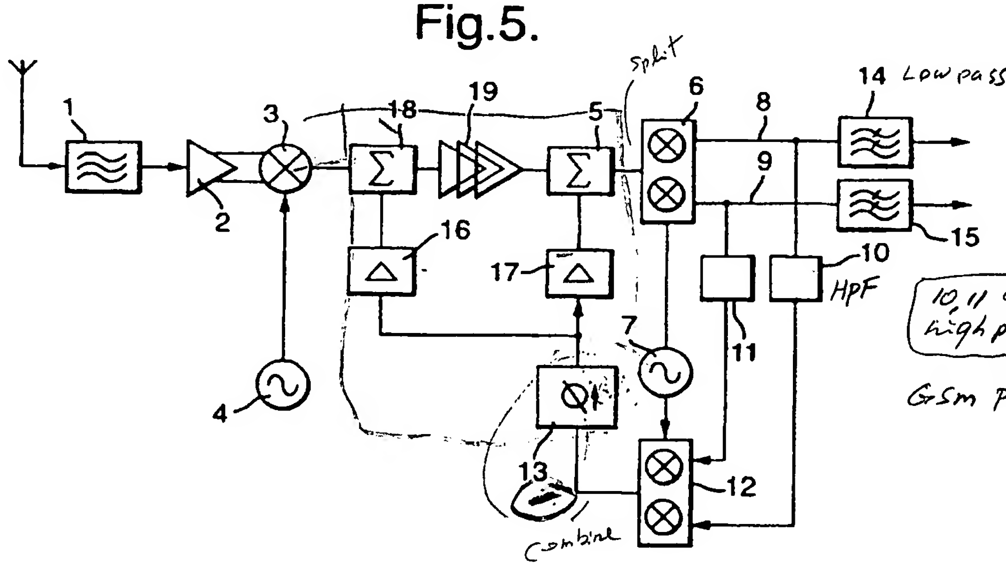
INT CL^3 **H03D 1/22 , H03J 5/00 , H04B 1/26 1/28 1/30**
ONLINE:WPI,EPODOC,PAJ

(54) Abstract Title
Receiver with feedback subtraction of unwanted signals to control bandwidth

(57) Multiple loop feedback is applied to broadband IF heterodyne or direct conversion radio receivers. Unwanted products from the output of the second down conversion mixer (6) are filtered out (10,11), restored to IF frequency (12) phase shifted (13) and added at the IF frequency to one or more inputs of the second mixer to cancel the unwanted products and linearize the mixer. When the feedback is applied to a single input of the mixer, it is added via two signal paths e.g. two summing junctions. By adding the feedback at the IF frequency via more than one signal path the relatively high gain required is achieved without introducing a large DC offset. In direct conversion receivers the unwanted output signals from the mixer are added in antiphase to one or more RF inputs of the mixer via two feedback loops.

Fig.5.



10,11 are high pass filter

GSM P4.

GB 2 343 572 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

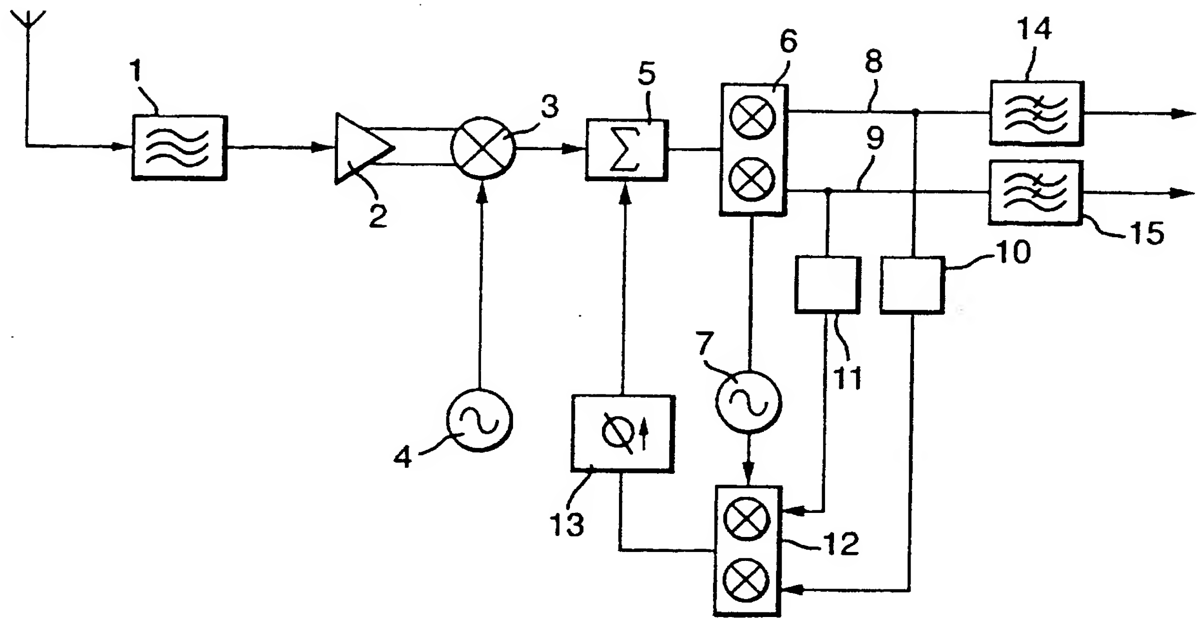


Fig.2.

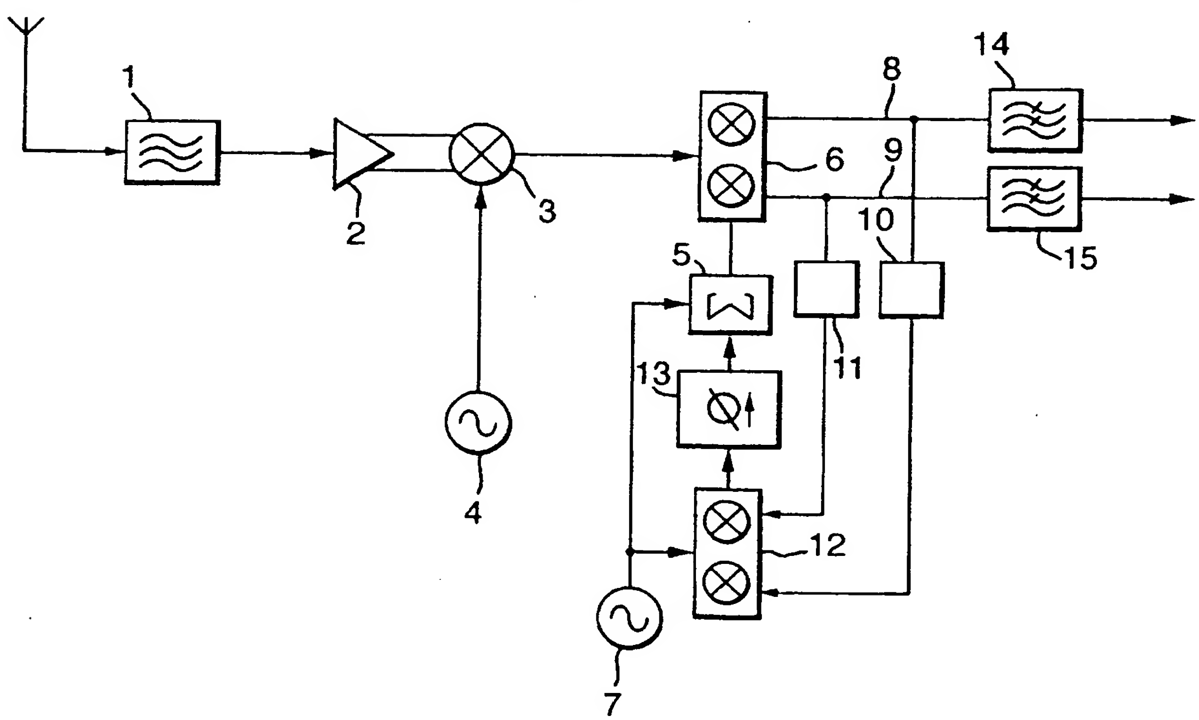


Fig.3.

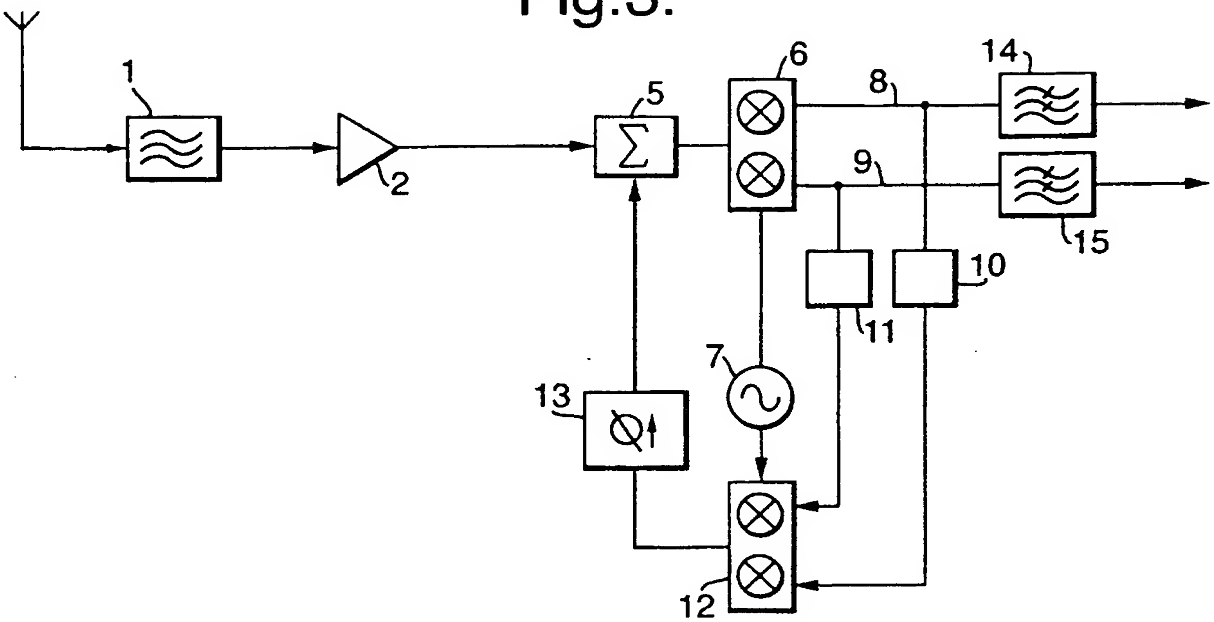


Fig.4.

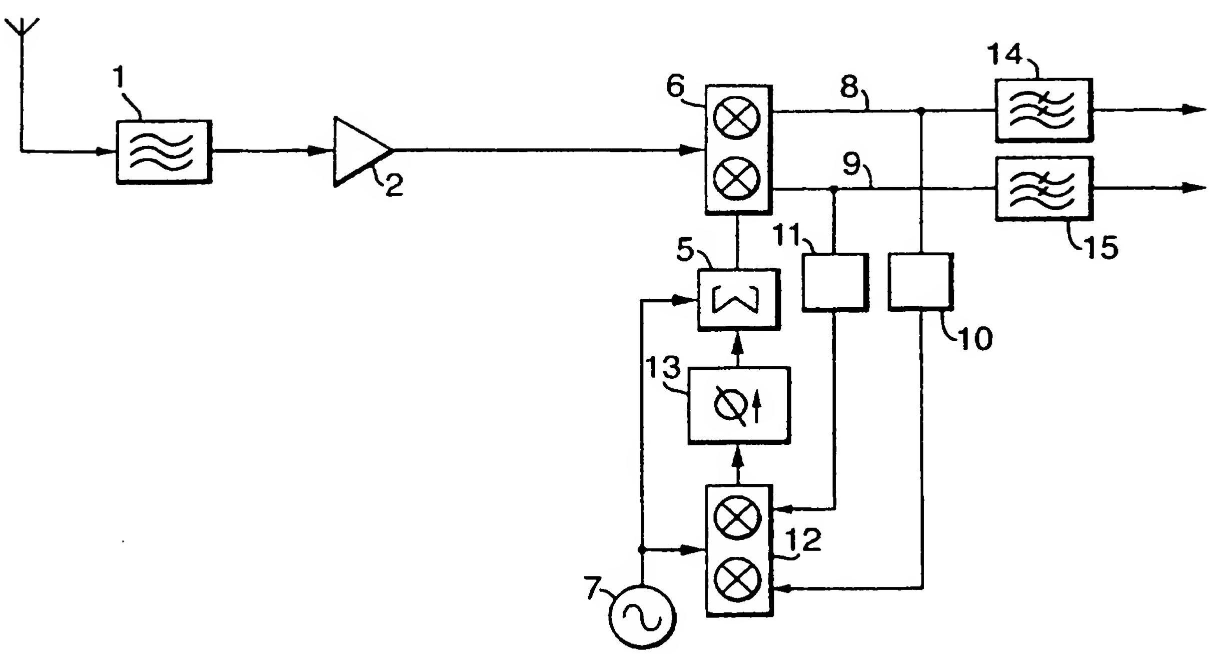


Fig.5.

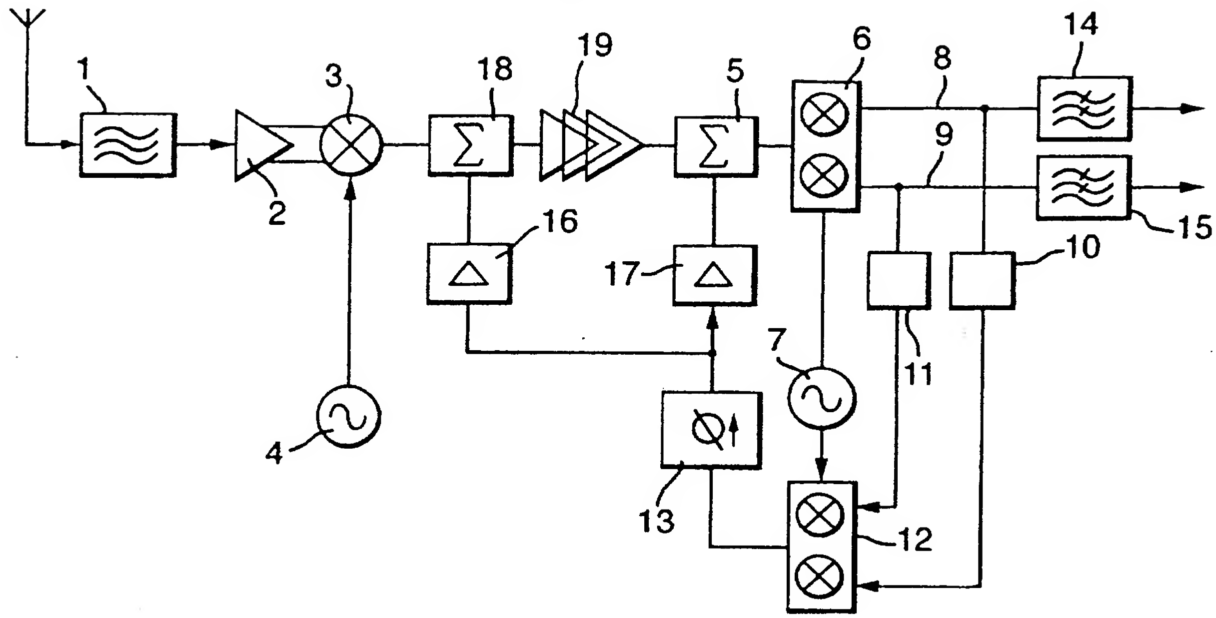

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Fig.6.

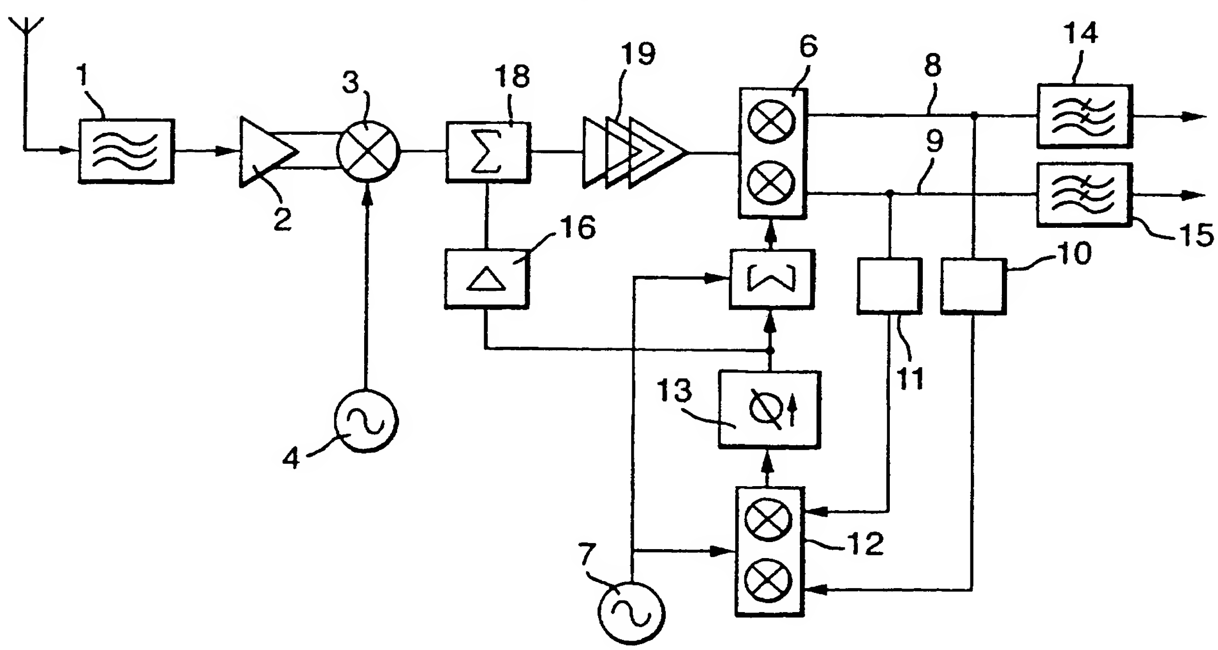
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Fig.7.

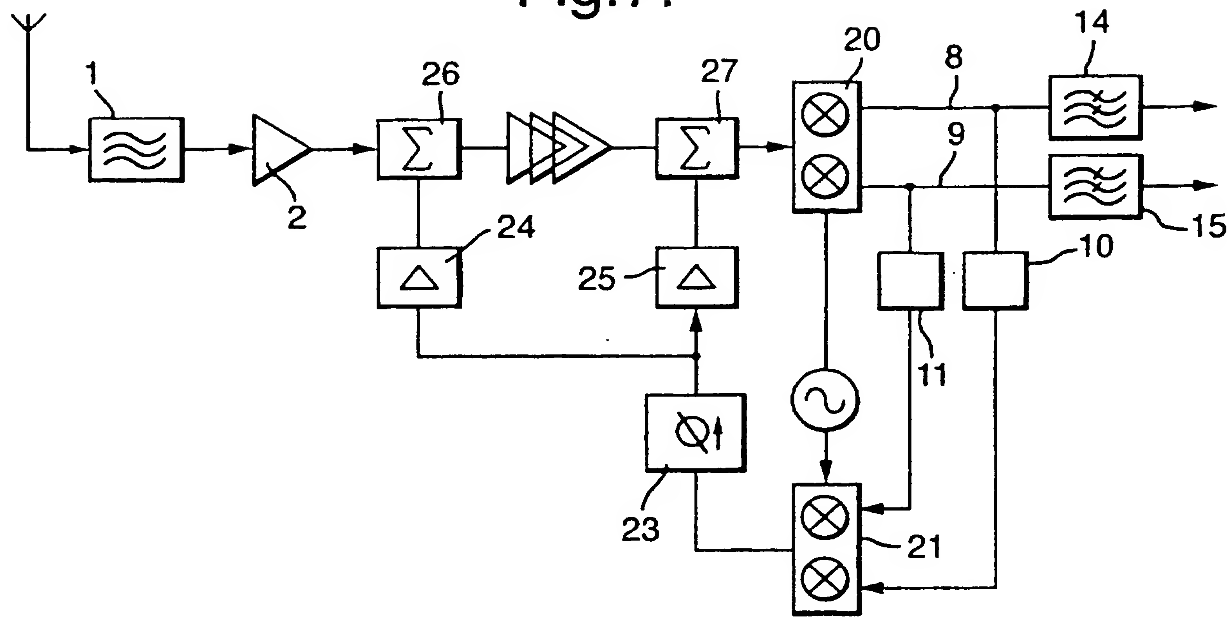
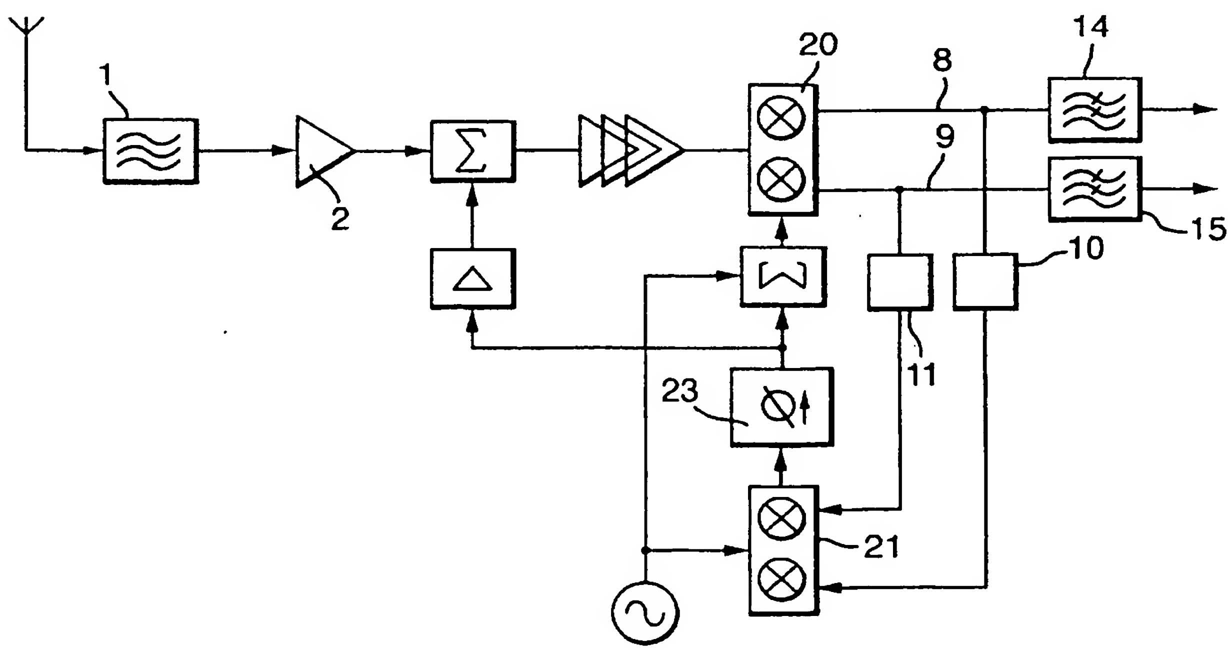


Fig.8.



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Radio receivers

This invention relates to radio receivers and it has particular utility for multi-mode mobile phones but is not so limited.

Most modern receivers are based on a conventional heterodyne topology. For a description of the prior art and technological background reference is made to the paper on " Recent Advances in RF Integrated Circuits" by Behzad Razavi published in IEEE Communications Magazine, December 1997. US 4 653 117 to Heck also discloses relevant prior art.

These conventional heterodyne receivers make use of a fixed IF and incorporate a narrow band IF filter designed to pass only the wanted signal and reject the large unwanted signals. The large unwanted signals, if not removed by the narrow band IF filter would otherwise compress/saturate the latter stages of the receiver i.e. the demodulator and so reduce the sensitivity of the receiver. The IF filter is normally a SAW device and so cannot be integrated into a semiconductor process.

Receivers designed to operate with networks having different radio standards generally have different data bandwidths and so the IF filter bandwidth would need to be changed to accommodate operation with the different bandwidths. Under existing arrangements the changes in IF filter bandwidth needed for multi-mode radio would require a plurality of SAW filters.

The following abbreviations and terminology are used herein:

GSM - *Global System for Mobile communications, (formerly Groupe Special Mobile)*

SAW - *Surface acoustic wave*

LNA - *Low noise amplifier*

ASIC - *Application specific integrated circuit*

IF - *Intermediate frequency*

RF - *Radio frequency*

MULTI-MODE - *This describes herein a capability to accommodate a number of different data bandwidths rather than different methods of multiple access. The receiver is not limited, however, to any particular multiple access method*

An object of the present invention is to provide a receiver with broadband IF and multi-mode capability which obviates the need for IF filters and can be implemented fully in ASIC. A further object of the invention is an improved multi-mode homodyne receiver. Further advantages anticipated for the invention are improved flexibility of frequency planning, reduction of the pass band group delay ripple normally associated with SAW filters and cost reduction through the elimination of SAW filters.

According to one aspect of the invention there is provided a heterodyne radio receiver, having a broadband IF, in which the outputs from the second down-conversion mixer of the receiver are high pass filtered to select unwanted signals and low pass filtered to select wanted signals, the unwanted signals being up-converted to IF in an up-conversion mixer, phase shifted and added in anti-phase to an input or inputs *of the second down-conversion mixer.*

According to a further aspect of the invention there is provided a homodyne radio receiver in which the outputs from the down-conversion mixer of the receiver are high pass filtered to select unwanted signals and low pass filtered to select wanted signals, the unwanted signals being up-converted to RF in an up-conversion mixer, phase shifted and added in anti-phase to an input or inputs *of the down-conversion mixer.*

Examples of the invention will now be described with reference to the figures in which like reference numerals identify identical elements and wherein:

figure 1 is a block diagram of a heterodyne receiver constructed in accordance with the invention,

figure 2 is a block diagram of a heterodyne receiver constructed in accordance with a further implementation of the invention,

figure 3 is a block diagram of a homodyne receiver constructed in accordance with the invention,

figure 4 is a block diagram of a homodyne receiver constructed in accordance with a further implementation of the invention.

figure 5 is a block diagram of a heterodyne receiver with multiple loop feedback,

figure 6 is a block diagram of a heterodyne receiver constructed in accordance with a further implementation of multiple loop feedback,

figure 7 is a block diagram of a homodyne receiver with multiple loop feedback,

figure 8 is a block diagram of a homodyne receiver constructed in accordance with a further implementation of multiple loop feedback.

3rd paragraph

*With reference to figure 1, a receiver system based on a broad band IF receiver is shown and comprises pre-selector filter **1**, LNA **2** first down-conversion mixer **3**, first local oscillator (LO) **4**, summer **5**, second (last) down-conversion mixer **6**, second LO 7, I and Q baseband outputs **8** and **9**, high pass filters **10** and **11**, up-conversion mixer **12**, phase shifter **13** and low pass filters **14** and **15**.*

4th paragraph

In this type of system the whole of the wanted band i.e. 25MHz for GSM, is mixed down from the incoming RF to an IF (say 250Mhz). All of the input levels are increased by the LNA and first mixer gain so it would be quite typical for the demodulator to experience interfering levels of 0dBm. As the typical input compression point of a low current demodulator is -10dBm saturation would occur under these conditions.

This invention linearises the demodulator function by cancellation of the unwanted products. A feedback loop is implemented around the last down-conversion mixer and for ease of explanation the system will be described starting from the output of the down-conversion mixer.

1st paragraph

At the output of the demodulator all the products from the second down-conversion mixer ***6****, both wanted and unwanted, are produced on the I and Q lines* ***8*** *and* ***9****. This base band energy is high pass filtered in filters* ***10*** *and* ***11*** *such that the unwanted signals are passed and the desired signals rejected by filters* ***10*** *and* ***11****. For example in a GSM receiver the filters* ***10*** *and* ***11*** *can have a 100kHz high pass corner frequency. The outputs from filters* ***10*** *and* ***11*** *are connected to the input I and Q lines of the quadrature modulator, up-conversion mixer* ***12****.*

The local oscillator port of the up-conversion mixer ***12*** *is connected to second LO* ***7****, the same LO that is used by the second down-conversion mixer* ***6*** *so that at the output of the up-conversion mixer* ***12*** *the unwanted products are reconstructed at the IF frequency. The output of up-conversion mixer* ***12*** *is connected to a fixed phase shifter* ***13****, the phase of phase shifter* ***13*** *being set so that the total phase shift around the loop is 180 degrees.*

The two inputs of unwanted signal products to summer ***5****, the unwanted signals contained in the broadband IF and the reconstructed unwanted signals fed back, are therefore preferably in complete anti-phase to achieve cancellation. It has been found, however, that a phase change of exactly 180 degrees around the loop is not necessary for the invention to be effective. The output of phase shifter* ***13*** *is connected to a summing junction* ***5*** *which has high port isolation (i.e. the order of 30dB). It is at the summing junction that the cancellation of the unwanted products occurs.*

anti phase
cancel
unwanted

The reduction in the levels of unwanted signal products input to the second down-conversion mixer ***6*** *effectively increases the linearity of mixer* ***6****.*

The outputs from the second down-conversion mixer **6** *are also passed on the I and Q lines* **8** *and* **9** *to low pass filters* **14** *and* **15** *and then to the usual processing stages which are described e.g. in "Mobile Radio Communications" published by John Wiley & Sons, Raymond Steele (Ed.) 1992 . The low pass filters* **14** *and* **15** *and the high pass filters* **10** *and* **11** *may be active filters and may be constructed as MMIC active filters, a description of which can be found in IEEE Transactions on Microwave Theory and Techniques, Volume 37, number 12 December 1989, Manfred J. Schindler and Yusuke Tajima.*

The receiver may be programmed to change the corner frequencies of low pass filters **14** *and* **15** *and high pass filters* **10** *and* **11** *thereby automatically to select the passband required for a particular mode of operation.*

With reference to figure 2, a receiver block diagram shows a further example of a receiver which allows the invention more easily to be implemented by means of a semiconductor process . The principle of operation for the receiver of figure 2 remains the same as that for the receiver shown in figure 1. Cancellation of the unwanted signals by feedback still occurs but in the receiver of figure 2 the unwanted signals are cancelled within the second down-conversion mixer **6** *rather than at its input.*

Consider the output of second down-conversion stage **6** *where both the wanted and unwanted products are produced. The high pass filters* **10** *and* **11** *connected to the output I and Q lines from second down-conversion stage* **6** *pass the unwanted signals to the input of up-conversion mixer* **12**. *The*

*output from the second local oscillator LO 7 is fed as an input to up-conversion mixer **12** and LO 7 is fed also via summer **5** to the down-conversion mixer **6**. The unwanted signals are reconstructed at their original IF frequency in up-conversion mixer **12** . These unwanted signals at the output of up-conversion mixer **12** are phase shifted in phase shifter **13** with a fixed phase shift so that the total phase around the loop is equal to 180degrees.*

1st paragraph

*The output of phase shifter **13** is summed with the LO 7 output to produce a "LO signal plus unwanted signal" as an input to the down-conversion mixer **6** LO port. Cancellation of the unwanted signals is effected within the demodulator through the process of destructive interference thereby effectively linearising down-conversion mixer **6**. In the receiver arrangement of figure 2 the summing junction **5** operates at lower power levels than in the arrangement of figure 1 and so may more easily be implemented in a semiconductor process .*

The receivers shown in figure 3 and 4 are homodyne receivers and the incoming RF is converted directly to baseband by a single down conversion mixer. A single local oscillator with output frequency at RF is used. The up conversion mixers for the homodyne receivers reconstruct at RF the unwanted baseband signals from the high pass filters.

The loop from the output of the last (single) down conversion mixer through high pass filters, up-conversion mixer, phase shifter and summer to an input of the down conversion mixer is as described above for the heterodyne receivers. In the receiver of figure 3, the up-converted unwanted signals are

added at RF in anti-phase to the RF input of the down-conversion mixer. In the receiver of figure 4 the up-converted unwanted signals at RF are combined with the local oscillator output prior to being added in anti-phase to the local oscillator input of the down-conversion mixer.

Owing to the port isolation (around 30dB) of the summing junctions and mixers the embodiments described above demand that a considerable level of gain be generated at baseband. The generation of high levels of gain at baseband can introduce additional design difficulties e.g. a large initial dc offset to be removed by calibration.

With reference to the heterodyne receiver of figure 5, the up-converted unwanted signals are added in anti-phase to the broadband IF input of the second down-conversion mixer by a plurality of summing junctions. 3rd paragraph
The unwanted signals in the output from second down-converter **6** are passed via high pass filters **10** and **11** to up-conversion mixer **12** in the same manner as in the embodiments shown in figures 1 to 4. The output from up-conversion mixer **12** is fed to phase shifter **13** and the output from phase shifter **13** is supplied as an input to both amplifier **16** and amplifier **17.** Amplifier **16** feeds summer **18** and amplifier **17** feeds summer **5.** The receiver of figure 5 enables the required gain to be generated at IF by means of multiple loop feedback and simplifies the baseband design. Additionally the port isolation is effectively doubled (to about 60dB)

With reference to figure 6, the unwanted signals up-converted to IF in up-conversion mixer **12** are phase shifted in phase shifter **13** and added in anti-

phase to the IF input and the local oscillator input of the second down-conversion mixer.

Figures 7 shows the application of multiple feedback loops to provide anti-phase addition of the unwanted signals to the RF input of the single down-converter mixer. The unwanted signals filtered at baseband at **8** and **9** by high pass filters **10** and **11** are up-converted to RF in up-conversion mixer **21**, phase shifted in phase shifter **2**, amplified in amplifiers **24** and **25** and applied to summers **26** and **27**.

A homodyne radio receiver is shown in figure 8 in which the outputs from the down-conversion mixer of the receiver are high pass filtered to select unwanted signals and low pass filtered to select wanted signals, the unwanted signals being up-converted to RF in an up-conversion mixer, phase shifted and added in anti-phase to the RF input and to the local oscillator input of the down-conversion mixer.

In the block diagram of figure 8 the up-converted unwanted signals at RF are added in anti-phase to both the RF input and the local oscillator input of the single down-converter mixer **20**.

Claims

1. *A heterodyne radio receiver, having a broadband IF, in which the outputs from the second down-conversion mixer of the receiver are high pass filtered to select unwanted signals and low pass filtered to select wanted signals, the unwanted signals being up-converted to IF in an up-conversion mixer, phase shifted and added in anti-phase to an input* or inputs *of the second down-conversion mixer.*

2. A heterodyne radio receiver as in claim 1 in which the up-converted unwanted signals are added in anti-phase to the broadband IF input of the second down-conversion mixer by a plurality of summing junctions

3. A heterodyne radio receiver, having a broadband IF, in which the outputs from the second down-conversion mixer of the receiver are high pass filtered to select unwanted signals and low pass filtered to select wanted signals, the unwanted signals being up-converted to IF in an up-conversion mixer, phase shifted and added in anti-phase to the IF input and to the local oscillator input of the second down-conversion mixer.

4. A heterodyne radio receiver as in claims 1 to 3 in which the anti-phase addition of unwanted up-converted signals to the second down-conversion mixer is by means of multiple loop feedback.

5. A homodyne radio receiver in which the outputs from the down-conversion mixer of the receiver are high pass filtered to select unwanted signals and low pass filtered to select wanted signals, the unwanted signals being up-converted to RF in an up-conversion mixer, phase shifted and added in anti-phase to an input or inputs *of the down-conversion mixer.*

6. A homodyne radio receiver as in claim 5 in which the up-converted unwanted signals are added in anti-phase to the broadband IF input of the second down-conversion mixer by a plurality of summing junctions.

7. A homodyne radio receiver in which the outputs from the down-conversion mixer of the receiver are high pass filtered to select unwanted signals and low pass filtered to select wanted signals, the unwanted signals being up-converted to RF in an up-conversion mixer, phase shifted and added in anti-phase to the RF input and to the local oscillator input of the down-conversion mixer.

8. A homodyne radio receiver as in claims 5 to 7 in which the anti-phase addition of unwanted up-converted signals to the second down-conversion mixer is by means of multiple loop feedback.

9. A radio receiver as in any preceding claim in which the baseband outputs from the last down-conversion stage of the receiver are filtered by means of active filters.

10. A radio receiver as in claim 11 in which the active filters are MMIC filters.

11. A radio receiver as in any preceding claim programmed to change the corner frequencies of low pass filters and high pass filters automatically to select the passband required for a particular mode of operation.

12. A radio receiver as in any preceding claim in which the receiver is implemented as an ASIC.

AMENDMENTS TO THE CLAIMS HAVE BEEN FILED AS FOLLOWS:

Claims

1. A heterodyne radio receiver, having a broadband IF, in which the outputs from the second down-conversion mixer of the receiver are high pass filtered to select unwanted signals and low pass filtered to select wanted signals, the unwanted signals being up-converted to IF in an up-conversion mixer, phase shifted and added to the second down-conversion mixer via multiple loop feedback.

2. A heterodyne radio receiver as in claim 1 in which the up-converted unwanted signals are added in anti-phase to the broadband IF input of the second down-conversion mixer by a plurality of summing junctions

3. A heterodyne radio receiver as in claim 1 in which the up-converted unwanted signals are added in anti-phase to the broadband IF input of the second down-conversion mixer and to the local oscillator input of the second down-conversion mixer.

4. A homodyne radio receiver in which the outputs from the down-conversion mixer of the receiver are high pass filtered to select unwanted signals and low pass filtered to select wanted signals, the unwanted signals being up-converted to RF in an up-conversion mixer, phase shifted and added to the down-conversion mixer via multiple loop feedback.

5. A homodyne radio receiver as in claim 4 in which the up-converted unwanted signals are added in anti-phase to the RF input of the down-conversion mixer in a plurality of summing junctions.

6. A homodyne radio receiver as in claim 4 in which the up-converted unwanted signals are added in anti-phase to the RF input of the down-conversion mixer and to the local oscillator input of the down-conversion mixer.

7. A radio receiver as in any preceding claim in which the baseband outputs from the last down-conversion stage of the receiver are filtered by means of active filters.

8. A radio receiver as in claim 7 in which the active filters are MMIC filters.

9. A radio receiver as in any preceding claim programmed to change the corner frequencies of low pass filters and high pass filters automatically to select the passband required for a particular mode of operation.

10. A radio receiver as in any preceding claim in which the receiver is implemented as an ASIC.

11. A radio receiver substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

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Application No:	GB 9824421.3	**Examiner:**	D Midgley
Claims searched:	1-12	**Date of search:**	30 March 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H3Q QDRD,QDRS,QEDB H3R RADC

Int Cl (Ed.6): H03D 1/22 H03J 5/00 H04B 1/26,1/28,1/30

Other: ONLINE:WPI,EPODOC,PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	EP 0580269 A2	(SYSTRON) See, for example, column 1, lines 16-26	1,3,5,7
X	EP 0087123 A2	(DONATH) See, for example, page 11, line 23 to page 12, line 17	"

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Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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E Patent document published on or after, but with priority date earlier than, the filing date of this application.